

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>NOV 2011</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>The Light Weight Body Structure Technologies of Lexus LFA</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Toyota Motor Corporation, 1 Toyota-cho Toyota, Aichi 471-8572, JAPAN</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>See also ADA557371. Japan International SAMPE Symposium &amp; Exhibition (12th) (JISSE-12) Held in Tokyo, Japan on November 9-11, 2011. Approved for public release. U.S. Government or Federal Purpose Rights License., The original document contains color images.</b>					
14. ABSTRACT <b>Lexus LFAs CFRP body structure has been developed from the ground level within Toyota. The development team has spent countless hours on technical discussions, especially as most of the member were not experienced at all in CFRP material and manufacturing processes. This was the main reason why we have chosen to take the burden of the learning curve on our own, so that we understand better, the key characteristics of the composite material. In fact, Toyota is one of the few automotive companies who manufacture CFRP body structure entirely in an in-house production site. Difficult enough as it is, we have also chosen to challenge various technologies other than the state of the art prepreg-autoclave moulding, such as braiding, stitching, RTM, etc., to enhance performances and to simplify manufacturing processes</b>					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>2</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# The Light Weight Body Structure Technologies of Lexus LFA

Nobuya Kawamura

Toyota Motor Corporation, 1 Toyota-cho Toyota, Aichi 471-8572, JAPAN

## ABSTRACT

Lexus LFA's CFRP body structure has been developed from the ground level within Toyota. The development team has spent countless hours on technical discussions, especially as most of the member were not experienced at all in CFRP material and manufacturing processes. This was the main reason why we have chosen to take the burden of the learning curve on our own, so that we understand better, the key characteristics of the composite material. In fact, Toyota is one of the few automotive companies who manufacture CFRP body structure entirely in an in-house production site. Difficult enough as it is, we have also chosen to challenge various technologies other than the state of the art prepreg-autoclave moulding, such as braiding, stitching, RTM, etc., to enhance performances and to simplify manufacturing processes.

**KEYWORDS:** LFA, CFRP, automotive, body structure

## 1. INTRODUCTION



Our challenge to develop a complete original CFRP car body structure has started in 2004 as a backyard project involving just a few numbers of people, mainly from different engineering offices within Toyota's technical centre. LFA's vehicle development itself had started from year 2000, originally with an aluminium body structure. No doubt that Toyota's involvement in Formula 1 racing activity had an influence, when we started to develop a version of the LFA with CFRP body structure in parallel to that of aluminium. Compared to less than a dozen race cars per year to be build, engineering tasks necessary for a commercial vehicle of a series production is far from similar. Never the less, we have succeeded in introducing a top performance super sports vehicle, thanks to many bench mark examples, as well as support and advices from the fore runners in the industry and the academics.

## 2. Light Weight Body Structure Development

### 2.1 Design Target

Aiming to achieve top performance, the weight and the stiffness target of LFA body had been set to less than 200kg with more than two times higher stiffness of the typical passenger cars. At the time of the development, the most referable series production vehicles in the same market range were Porsche Carrera GT, and McLaren SLR. Porsche had chosen completely conventional prepreg and autoclave approach whereas, McLaren utilized RTM technology in many areas. It was decided for the LFA to start with the prepreg method to maximise our confidence level towards the performance realisation of composite body structure, but eventually, modifications towards RTM, SMC, and etc. had taken place during the prototype phases as we gather more data and experiences. Thus, a weight of 193kg and torsion stiffness exceeding twice the average has been achieved (fig. 1, fig.2).

### 2.2 Material and Process Development

For the main portion of the LFA's CFRP body structure, a specifically developed biaxial NCF fabric is utilised. Based on this fabric together with viscosity tuned thermo set epoxy matrix, a very unique semi-prepreg has been further developed, allowing out of autoclave processing due to its enhanced air evacuation property (fig.3). Another prepreg version, this time with thermoplastic epoxy matrix, has been developed for impact energy absorption structure embedded within the side sill of the CFRP body (fig. 4). The same NCF fabric, with fine tuning of the stitching parameters to enhance drapability of the dry fabric, with an addition of preforming agent, has been developed for the compression injection RTM moulding of the floor module (fig. 5).

Carbon fibre reinforced SMC based on vinyl ester matrix was also developed for the upper body structure, allowing complicated shape to be moulded in one-shot. Application of such material still requires many fine-tuning for the process set up, as it is much

more difficult to flow compared to glass fiber SMC with unsaturated polyester matrix. Special care towards weld line generations and fiber turbulence creating stress points through the cross section, needs to be considered.

3D braiding of an A-pillar + roofside rail modular structure was another challenge starting with the equipment development. This part, which is RTM moulded, is completely hollow inside, with varying cross section sizes (fig. 6).

Front crash box, for absorbing the frontal crash impact energy, is made of CFRP with a unique 3D stitching technology (fig.7). The advantage of such a manufacturing method is the increase in energy absorption (fig.8).

### 3. Summary

As briefly explained above, we have successfully developed and launched the Lexus LFA with CFRP with light weight, high stiffness CFRP body structure, based on originally developed technologies. As for the future possibilities to expand CFRP technologies in automotive applications, I must emphasize two major tasks of importance. Firstly, we must realise much higher processing capability in terms of time and simplicity, to enable through put of part quantities required for mass production vehicles. Secondly, the cost of the CFRP material need to be lowered dramatically in order for the car price to meet market requirements. Modular shape moulding of RTM or fast and automated processing of SMC may be the initiation to such efforts. Thermalplastic CFRP, as we have demonstrated, could be also interesting. Anyhow, the industry and the academics must cooperate and energetically continue to challenge these difficult targets, so that LFA and others alike does not end as another niche product in the market.

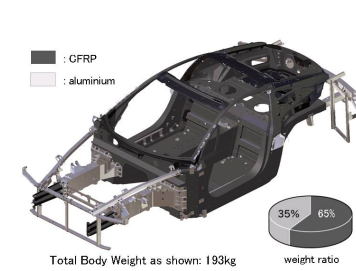


Fig.1 CFRP Body Structure

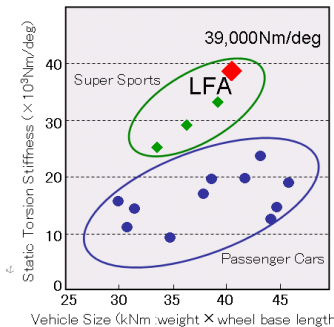


Fig.2 Body Stiffness Comparison

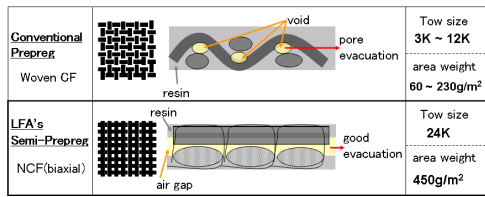


Fig.3 NCF semi-prepreg

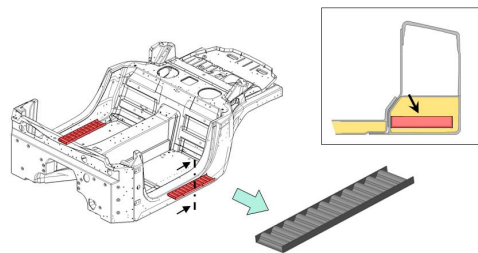


Fig.4 Thermal plastic CFRP

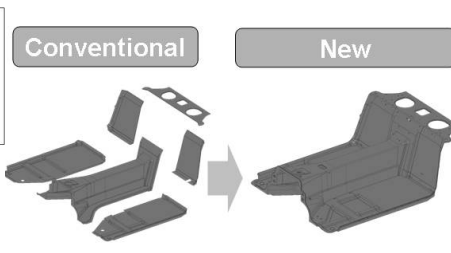


Fig.5 One-shot Moulding by RTM

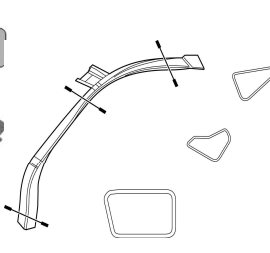


Fig.6 Braided A-pillar

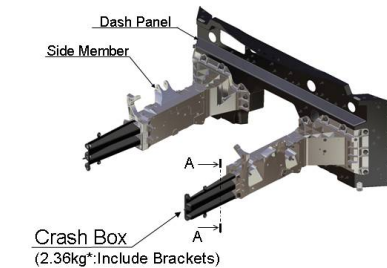


Fig.7 3D Stitched Front Crash Box

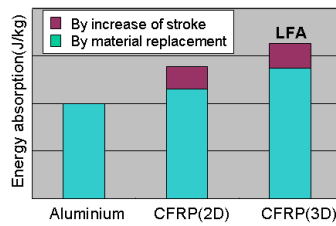


Fig.8 EA Efficiency Comparison